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(19)

(54) IMPROVEMENTS IN OR RELATING TO A SILENCER DEVICE FOR ABSORBING THE NOISE OF THE EXHAUST GASES OF AN ENGINE

(71) I, FERNAND MAURICE PLESSY, a French Citizen of 117, rue Grande, Moncourt-Fromonville 77880 Grez-Sur-Loing, France, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to devices termed "silencers" for muffling or absorbing the noise produced by the exhaust of the burnt gases of internal combustion or explosion engines.

Devices are known which are based on the principle of acoustic filtration and essentially comprise putting the exhaust pipe in communciation with a series of absorbing cells or compartments the capacity of which is determined in accordance with the section of the exhaust pipe and the frequency of the sounds to be absorbed.

When employed with engine exhaust pipes, these devices have a serious drawback which results from the condensation of steam contained in the exhaust gases. The water of condensation is deposited in the lower part of the compartments surrounding the exhaust pipe and progressively reduces their free volume and consequently their sound-absorbing capacity and results in a reduction in the effectiveness of the device.

According to the present invention there is provided a silencer device for absorbing noise of exhaust gases from an engine, comprising an elongate exhaust passage through which the gases are in use conducted, a plurality of acoustic filtration compartments the walls of which are constituted by an outer wall surrounding the exhaust passage, by the exhaust passage itself and by partition walls extending transversely of the exhaust passage from the outer wall to the exhaust passage, and a plurality of openings in the exhaust passage for putting the interior of the exhaust passage in communication with each of the compartments, wherein each of the said openings communicates with one only of the compartments, the opening or openings communicating with any one of the compartments lying substantially within a single transverse plane of the exhaust passage, and wherein the exhaust passage is arranged relative to the outer wall such that substantially all of any liquid which collects in any one of the compartments in use of the device drains or tends to drain from the compartment into the exhaust passage.

In one embodiment of the invention, which is particularly advantageous in the case of small engine capacities in which it is of interest to reduce the section of the exhaust passage (e.g. a pipe) without increasing its resistance to the flow of the gases, the part of this pipe located in the silencer is of constricted section, the part located adjacent the inlet of the silencer converging in a downstream direction and the part adjacent the outlet diverging in the same direction. The convergent part at the outlet acts to increase the velocity of the gases in the pipe which permits, for a given flow, a reduction in the cross-section of the gas passage, and the divergent part at the outlet ensures an increase in the pressure at the outlet in order to overcome more easily atmospheric pressure.

Experiments have shown that, with this arrangement, the reduction in the cross-section of the exhaust pipe at the inlet of the silencer ensures with certainty the beneficial silencing effect produced by the said openings in communication with the acoustic filtering hereinafter called absorbing compartments, with practically no pressure drop along the pipe.

In another embodiment of the invention, an expansion chamber is interposed in the exhaust pipe upstream of the absorbing compartments. It has been found that the presence of this expansion chamber can markedly improve the acoustic effectiveness of the silencer device of the invention.

The cross-section of the exhaust pipe can be determined in such manner that the gases in the pipe are subjected to the particular silencing effect produced by the openings of communication with the absorbing compartments throughout the whole cross-section of the pipe.

Further features and advantages of the invention will be apparent from the ensuing description which is by way of example and is with reference to the accompanying drawings in which:

Fig. 1 is a partial longitudinal sectional view of one embodiment of the silencer device according to the invention;

Fig. 2 is a sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1 of another embodiment;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 3;

Fig. 5 is a view similar to Fig. 1 of another embodiment;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 5;

Fig. 7 is a view similar to Fig. 1 of another embodiment;

Fig. 8 is a sectional view taken on line 8—8 of Fig. 7;

Fig. 9 is a view similar to Fig. 1 of another embodiment;

Figs. 10—14 are views similar to Fig. 2 of five other embodiments, and

Fig. 15 is a longitudinal sectional view of another embodiment comprising an expansion chamber and absorbing compartments.

With reference to the embodiment shown in Figs. 1 and 2, the reference numeral 1 designates an exhaust pipe in which, in use, gases flow in the direction of arrow *f*. The sound absorbing or muffling compartments are constituted by a cylindrical case 2 divided into a number of filtration compartments 3 otherwise called "cells" by partition walls 4. The pipe 1 bears on the bottom of the cases and communicates with each one of the compartments 3 by way of openings 5 arranged in a transverse section and about half way along the length of the corresponding compartment 3 in the longitudinal direction of the pipe 1.

The masses of gas contained in the compartments 3 act by elasticity so as to progressively absorb or muffle through the openings 5 the sound vibrations which are propagated by the exhaust gases.

Owing to the positioning of the pipe 1 on the bottom of the case 2, the water of condensation cannot stay in the bottom of the compartments 3 since it flows into, and is driven along the pipe 1 by the gaseous current therein.

The number of compartments is a function of the size and frequency of the current vibrations to be absorbed or muffled and the diameter of the pipe 1 is so determined that the silencing effect herein referred to as the "gas steam sectioning effect" produced by the diametrally opposed openings is propagated to the central part of the cross section of the pipe which is thus subjected to this sectioning effect throughout its area.

Experiments have shown that this sectioning effect is propagated only over relatively short distances and that when the diameter of the pipe 1 exceeds 20 mm, its centre part is not subjected to the sectioning effect. The embodiment shown in Figs. 1 and 2 can therefore only be suitable for small engine capacities of less than 100 cc.

This observation leads to the use of the embodiment shown in Figs. 3—8 when the capacity of the engine is larger.

In the embodiment shown in Figs. 3 and 4, there is employed a nest or group of pipes 6 disposed in the case 2, the lower pipe ensuring the discharge of the water of condensation from the case 7.

In the embodiment shown in Figs. 5 and 6, a single narrow pipe 7 is employed which has a rectangular cross-section, extends throughout the height of the case 2 and communicates with the compartments 3 by way of openings 8 in the form of slots formed in the planar sides of the pipe 7.

In the embodiment shown in Figs. 7 and 8, a plurality of pipes 9, similar to the pipe 7 shown in Figs. 5 and 6, are employed. Moreover, in order to improve the sound absorbing or muffling effect of the apparatus and broaden the range of absorbed frequencies, particular sub-groups of compartments 3 within the group of compartments of the silencer can be different volumes, so as to be adapted to damp different frequency ranges.

Experiments have shown that is is possible, with the device according to the invention, to obtain by very simple means excellent damping of the exhaust noise while operating as a free exhaust, that is to say practically without any substantial pressure drop, which may permit a gain in power of the order of 3—5%.

In the embodiment shown in Fig. 9, a part 16 of the pipe 11 which extends through the case 2 is of reduced diameter i.e. of constricted section, this part 16 being connected to the exhaust pipe 11 by a convergent part 17 at the inlet of the silencer and a divergent part 18 at the outlet of the latter.

This reduction in the diameter of the pipe 11 reduces the volume and weight of the silencer and makes it more certain that the sectioning effect produced by the openings 15 communicating with the absorbing compartments or cells 3 extends across the full cross-section of the pipe 1. Moreover, this reduction in section of the exhaust pipe in the part thereof extending through the silencer results in practically no pressure drop since the divergent part recovers in the form of pressure the increase in velocity that the gases underwent in the region of the convergent part and the atmospheric counterpressure is thus overcome more easily at the outlet of the exhaust pipe. Bearing in mind the small section of the exhaust pipe in the part thereof extending through the silencer, this embodiment is particularly adapted to small-capacity engines.

For large-capacity engines, use is made of silencer devices of the type described hereinafter with reference to Figs. 10—14.

Fig. 10 shows an embodiment similar to that shown in Fig. 6 in which a narrow flat pipe 19, with a cross section having opposed straight sides and rounded ends and extending throughout the height of the compartments or cells with which its rounded lower part and upper part are in contact, comprises reinforcing flanges 20 which extend along the edges of the communication openings 15. The flanges 20 may be constituted, for example, by bent portions of the sheet constituting the wall of the exhaust pipe. These flanges 20 impart an improved stiffness to the pipe 19 and reduce the vibrations of its planar walls under the effect of pulsations resulting from the action of the compartments.

In the embodiment shown in Fig. 11, the exhaust pipe 19 is divided internally by longitudinally extending partition walls 21 lying in a plane normal to the major sides of the pipe 19 into a group of conduits which lie one above another throughout the height of the compartments 3. The thickness of the partition walls 21 is so adapted that the pipe 19 withstands without vibrations the pulsations due to the action of the compartments.

In the embodiment shown in Fig. 12, the portions 22 of the walls of the pipe extending between two consecutive partition walls 21 have a curved shape in cross section which ensures an improved performance over a planar shape in the presence of vibrations.

This result may also be obtained as shown in Fig. 13, with an exhaust pipe 19 constituted by a nest or group of tubes 23 of circular cross section which are arranged one above another throughout the height of the compartments or cells 3 and welded together.

Fig. 14 is a modification of the invention in which good performance of the pipe 19 in the presence of vibrations is obtained by giving to the pipe an elliptical shape, the minor axis of the ellipse being chosen in such manner that the pipe is subjected throughout its surface to the sectioning effect produced by the openings 15 of communication with the absorbing compartments.

Moreover, this sectioning effect may be improved by employing, with the silencers shown in Figs. 3 to 8 and 10 to 14 intended for large-capacity engines, the convergent-divergent assembly described with respect to Fig. 9 which also permits some reduction in the volume and weight of these silencers.

With reference to Fig. 15 there is shown a silencer device 10 comprising an assembly of absorbing or muffling cells or compartments which may conform to any of the embodiments described hereinbefore, and an expansion chamber 34 provided in the exhaust pipe 33 upstream of the assembly of absorbing compartments, that is to say, between the case 2 and the engine of the vehicle. Preferably, the volume of the chamber 34 is of the same order of magnitude as that of the case 2. Preferably, this chamber 34 is constituted by a cylindrical body 35 connected to the exhaust pipe 33 at the upstream end by an elongate frustoconical part 36 having a relatively small taper and, at the downstream end, by another frustoconical part 37 which has a larger taper than the part 36.

This cylindrical body may have a cross-sectional shape which is circular or flattened so as to increase the capacity of the chamber while allowing for ground clearance in a motor vehicle engine silencer.

Moreover, there may be provided in the expansion chamber 34, so that substantially all the exhaust gases flow through it, an anti-pollution device 38 which is, for example, disposed adjacent the downstream end of the chamber. It may be consituted, for example, by granular elements having catalytic properties.

It has been found that the presence of the expansion chamber 34 distinctly improves the acoustic results of the silencer device according to the invention, particularly at low frequencies, and that these results are still further improved by the presence of the anti-pollution device 38 in the chamber 34.

WHAT I CLAIM IS:—

1. A silencer device for absorbing noise of exhaust gases from an engine, comprising an elongate exhaust passage through which the

gases are in use conducted, a plurality of acoustic filtration compartments the walls of which are constituted by an outer wall surrounding the exhaust passage, by the exhaust passage itself and by partition walls extending transversely of the exhaust passage from the outer wall to the exhaust passage, and a plurality of openings in the exhaust passage for putting the interior of the exhaust passage in communication with each of the compartments, wherein each of the said openings communicates with one only of the compartments, the opening or openings communicating with any one of the compartments lying substantially within a single transverse plane of the exhaust passage, and wherein the exhaust passage is arranged relative to the outer wall such that substantially all of any liquid which collects in any one of the compartments in use of the device drains or tends to drain from the compartment into the exhaust passage.

2. A device as claimed in claim 1, wherein the exhaust passage comprises a group of component pipes.

3. A device as claimed in claim 1, wherein the exhaust passage has a generally flattened cross sectional shape and extends in use throughout the height of each of the compartments, and wherein the openings are in the form of slots.

4. A device as claimed in claim 3, wherein the exhaust passage has reinforcing flanges extending along edges of the said openings.

5. A device as claimed in claim 3, wherein the exhaust passage is divided internally by longitudinally extending partition walls lying in a plane normal to the major sides of the passage into a group of conduits lying one above another.

6. A device as claimed in claim 5, wherein those portions of the walls of the exhaust passage which extend between two consecutive partition walls have a curved cross sectional shape.

7. A device as claimed in claim 3, wherein the exhaust passage is divided into a group of flattened rectangular sectioned tubes.

8. A device as claimed in claim 2, wherein said group of component pipes extends throughout the height of each compartment, said component pipes being arranged adjacent, and fixed to, one other and having a circular cross sectional shape.

9. A device as claimed in claim 1, wherein the exhaust passage has an elliptical cross sectional shape and extends throughout the height of each of the compartments and wherein the openings are in the form of slots.

10. A device as claimed in any one of the preceding claims, wherein the exhaust passage has a part adjacent the outlet of the silencer device which diverges in the downstream direction of the passage.

11. A device as claimed in claim 10, wherein the exhaust passage has a part adjacent the inlet of the silencer device which converges in the downstream direction of the passage.

12. A device as claimed in any one of the claims 1—10, comprising an expansion chamber interposed in the exhaust passage upstream of the compartments.

13. A device as claimed in claim 12, wherein the volume of the expansion chamber is of the same order of magnitude as the total volume of all compartments and the portion of the exhaust passage which coacts with the compartments.

14. A device as claimed in claim 13, wherein the expansion chamber has a cylindrical body having, at its upstream end, a first elongate and frustoconical part having a relatively small taper and, at its downstream end, a second frustoconical part which is of larger taper than the first part.

15. A device as claimed in claim 12, 13 or 14, including an anti-pollution device in the expansion chamber through which in use, substantially all of the exhaust gases flow.

16. A device as claimed in any one of the preceding claims, wherein the cross-section of the exhaust passage is so determined as to be subjected throughout its surface to the gas stream sectioning effect as defined hereinbefore produced by the said openings.

17. A silencer device for absorbing the noise of the exhaust gases of an engine, substantially as hereinbefore described with reference to and as shown in Figs. 1 and 2, or Figs. 3 and 4, or Figs. 5 and 6, or Figs. 7 and 8, or Fig. 9, or Fig. 10, or Fig. 11, or Fig. 12, or Fig. 13, or Fig. 14, or Fig. 15 of the accompanying drawings.

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1539016 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

SHEET 1

FIG_1

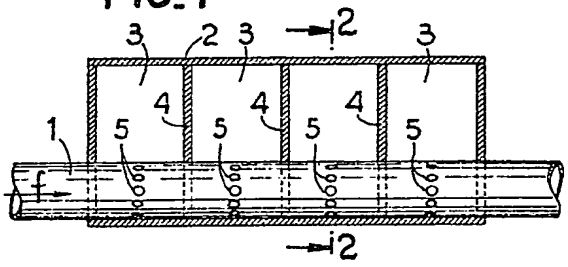


FIG_2

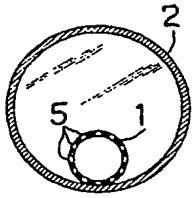


FIG_3

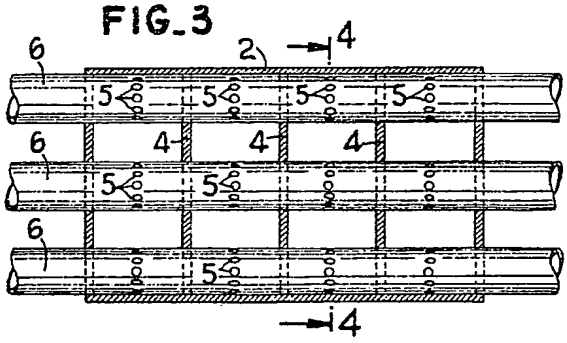


FIG_4

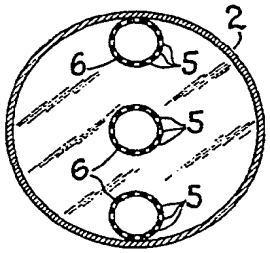


FIG_5

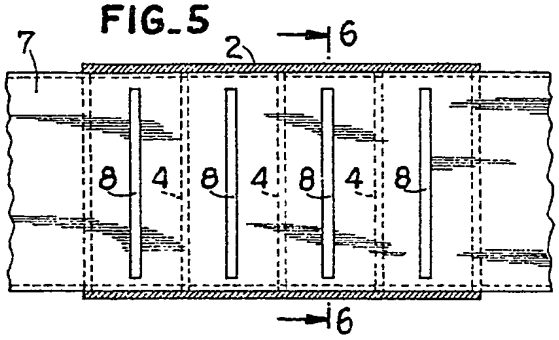


FIG_6

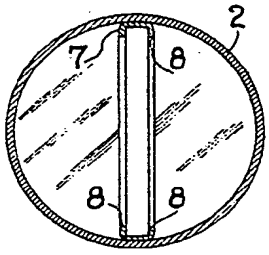


FIG_7

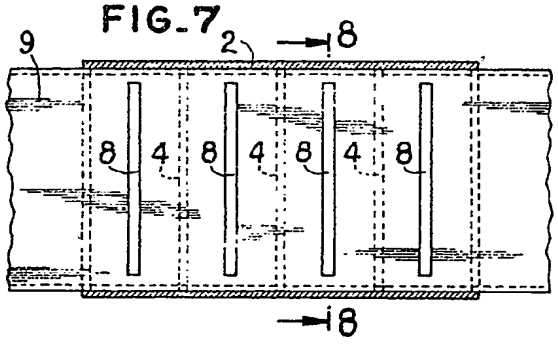
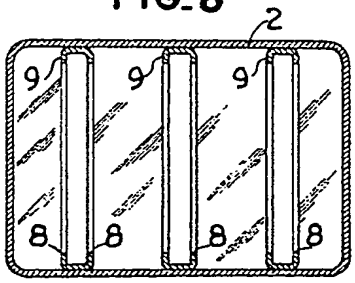


FIG_8



1539016 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

SHEET 2

FIG. 9

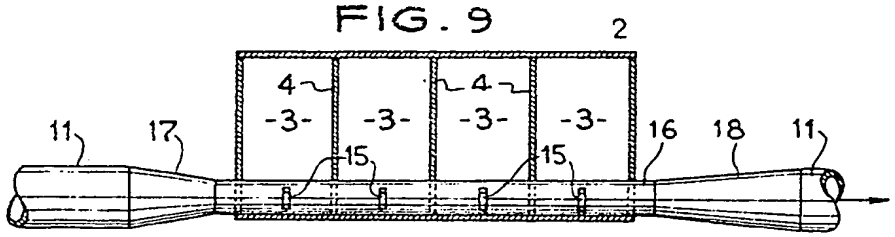


FIG. 10

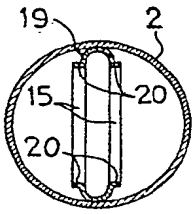


FIG. 11

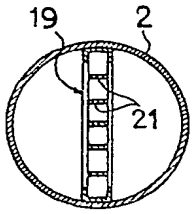


FIG. 12

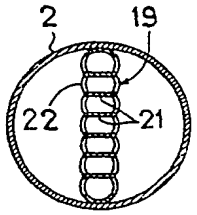


FIG. 13

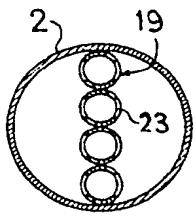


FIG. 14

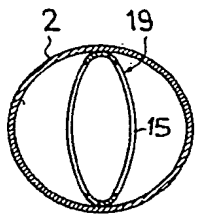


FIG. 15